tant is the recognition of the complexity and the protracted character of the glacial period as a whole. Until this is recognized, it will be difficult to prosecute work intelligently along the lines which must ultimately determine whether the rank of the several subdivisions is epochal or episodal.

A single word may be added with reference to Professor Geikie's chapter concerning the "Cause of the Glacial Climate." It has already been noted that the discussion of this subject has been relegated to the last chapter of the volume. In the course of this discussion it is evident that Professor Geikie holds much less strongly than heretofore to Croll's hypothesis of glacial climate. While he indicates that this hypothesis probably "contains a large element of truth" he does not regard it as a full solution of the vexed question. He further indicates that the complex phenomena of Europe "are evidence of a succession of changes too manifold, and perhaps occupying too short a space of time, to be accounted for by the cause to which Croll appealed." Professor Geikie's attitude seems to be well expressed in one of his closing sentences: "The primary cause of those remarkable changes is thus an extremely perplexing question, and it must be confessed that a complete solution of the problem has not yet been found."

ROLLIN D. SALISBURY.

Papers and Notes on the Glacial Geology of Great Britain and Ireland. By the late HENRY CARVILL LEWIS. Edited from his unpublished MSS., with an introduction, by HENRY W. CROSSKEY. Pp. lxxxi+469. Maps x., figures 83. London: Longmans, Green & Co., 1894.

Dr. Crosskey and the devoted wife of the late Professor Henry Carvill Lewis have placed all who are interested in glacial phenomena under lasting obligations by the publication, in elegant form, of the papers and notes of one who was among the most active and enthusiastic of American glacialists. It would have been a pleasure to the writer to have made earlier notice of this work, had not his absence from the country prevented. The book embraces papers on (1) Comparative Studies upon the Glaciation of North America, Great Britain and Ireland; (2) The Terminal Moraines of the Great Glaciers of England; (3) On some Important Extra-Morainic Lakes in Central England, North America, and elsewhere, during the period of maxi-

mum glaciation, and on the Origin of Extra-Morainic Bowlder Clay; (4) The Supposed Threefold Division of the Drift; (5) The Direction of Glaciation as ascertained by the Form of the Striæ; (6) Notes of observations made in the field, with their associated references, and with maps of routes and of the glaciated areas; (7) Memoranda and Brief Essays on various subjects connected with Glacial Geology; and, as appendices, (A) Extracts from the MSS. of Mr. Percy F. Kendall, and (B) Field Notes in Switzerland, Italy, South Germany, Belgium, and Holland. These papers and notes are presented as nearly in the form in which they were left by Professor Lewis as could be done consistently with a proper preparation for the press, Dr. Crosskey believing that this was both wiser and more loyal to his friend than any essential revision would be.

A peculiar interest attaches to the field notes of Professor Lewis, as they are thus frankly presented to us, because they open without reserve the door to his inner thoughts and impressions as they arose from day to day in the course of his rapid contact with new phenomena. We are permitted to see the advances, the oscillations and the occasional retreats of conviction that marked the application of his dominant working hypothesis to the problems he had undertaken. All who have had like experiences of oscillating conviction—and who has not—will find a sympathetic chord touched in the perusal of these notes.

Professor Lewis' method was distinctively that of the working hypothesis. While he entertained many supplementary hypotheses, and was by no means negligent of opposing hypotheses, there was one that was dominant and guided his work. The distributive affection that characterizes the system of multiple working hypotheses finds little expression in his investigations. With a strong faith in his chosen method, he sought to disentangle the intricate drift deposits of the British Isles by its energetic application. His working hypothesis sprang from his previous studies. During the decade preceding his notable work on the moraine of Pennsylvania, certain of the now older students of the drift, east and west, had detected a series of terminal moraines that had been previously overlooked or neglected, and had inaugurated the morainic method of discriminating and delineating the stages of glacial history. In the east the chief terminal moraine lay near the limit of the drift and was, for the time, supposed to be essentially coincident with it; in the west the chief moraines

lay at some distance back from the drift margin, and were not supposed to represent the full extent of the ice advance except locally, although correlated with those of the east. At the east, by virtue of the near coincidence of the moraine with the border of the drift, the word "terminal" came to have a double significance, in which *terminal to the drift* grew to be more prominent than *terminal to the ice* that formed it. It is needless to say that the latter is the original and true sense of the term, and that up to this time it had been employed almost exclusively in this sense in its application to the moraines of the Alps and elsewhere. Almost none of the previously recognized terminal moraines were marginal to the glacial deposits. The strength and definiteness of the outer terminal moraine in the Atlantic region, and the inconspicuousness of the drift outside it—which was almost overlooked for the time—naturally brought into great prominence the marginal position of the moraine, and fostered the development of the imported sense of the word "terminal." More than this, it led to the conviction that such a moraine was *characteristic* of the outer border of the glacial drift, if, indeed, it was not a necessary feature, and that by seizing upon it, and following it persistently, the precise limit of the ice advance might be definitely traced out and the true glacial drift distinguished from outlying drift transported by other agencies. It was this view, thus derived, that stimulated and directed the work of Professor Lewis in Great Britain and Ireland. His supreme effort was to detect and trace across the British Isles a moraine marginal to the true glacial drift, and to distinguish from this the outlying deposits which he believed to be formed by means other than direct glacier action.

The book sets forth by maps and clear descriptions the course of the moraine as traced by Professor Lewis, and also the nature and extent of the glacial movements that gave rise to it. It also presents the distribution of the marginal waters in Great Britain, by whose agency, in Professor Lewis' judgment, the extra-morainic drift was chiefly deposited. These were, in his opinion, mainly fresh waters, ponded back into lakes by the glacial obstruction of valleys and basins sloping *toward* the ice. He was led to very moderate views respecting the marine submergence of the land.

It must be left to British glacialists to say how far the delineations of Professor Lewis are likely to stand, but without doubt the introduction of the morainic method, and the definite mapping which he pre-

sented, must be regarded as a very stimulative contribution. The writer of this note does not agree with him in the belief that the *border* of the glacial drift is necessarily any more amenable to the morainic method than other portions; indeed, we think that European as well as American experience has already shown that it happens to be less so, as a major fact. The moraine-developing habit was most pronounced during the later part of the glacial period. More than this, we think it has been amply demonstrated that the border of the drift was formed at different times, and that the moraines that are marginal to it in one portion depart widely from it in other portions, one moraine lying on the border in one region, and another in another region, and that along a large portion of the border there is no conspicuous ridging of the drift. Nevertheless it is valuable to trace out any terminal moraine, whether it borders the drift or whether it separates drifts older from drifts younger, for it becomes, in any case, if successfully done, a tangible datum line for correlation.

Professor Lewis came to recognize, so far as England is concerned, that there was an earlier drift outside the moraine he mapped. Concerning this he says, p. 69 (*Postscript added to abstract printed in "Geological Magazine," November, 1887, p. 516*): "Since the paper [Extra-Morainic Lakes of England] was read of which the above is an abstract, I have found traces of the existence of a very much older series of glaciers than those here described.

"Since the period of these ancient glaciers, which in many places were more extensive than the modern ones, earth movements have occurred and erosion has removed almost all their deposits, and generally obliterated striæ, so that the region subject only to the older glaciation now resembles a non-glaciated area.

"The glaciers and their bordering lakes, described above should therefore be considered as belonging to the second or last glacial epoch."

And again, p. 390: "Recently I had found in the 'fringe' region of England evidence of a much more ancient glaciation; so old indeed that erosion had removed almost all the deposit and obliterated the striæ. Perched erratics occur above any possible lake. Is not this still due to an old glacier, and the red clay to an extra-morainic lake? Are they contemporary deposits? I find that the glaciers of the first epoch came from more southern centres than those of the second ice period."

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